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Northwestern Ontario Boreal Forest Management

Technical Notes

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CRITICAL SILVICS OF REINDEER LICHEN AS RELATED TO VEGETATION MANAGEMENT

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INTRODUCTION

This technical note is designed to assist resource managers in developing site specific vegetation management strategies. It follows the general format established by Bell (1991) and is one in a series of technical notes intended as addenda to the above mentioned document. Readers may wish to refer to Bell (1991) for background information.

The reindeer lichens (*Cladina* spp.), often referred to as reindeer mosses, are the focus of this paper (Figure 1). In particular, *Cladina mitis* (Sandst.) Hale and Culb., *C. rangiferina* (L.) Harm , and *C. stellaris* (Opiz) Brodo (formerly *Cladonia alpestris*) are discussed. As some terminology used in the text may be unfamiliar to the reader, a glossary of terms has been included.

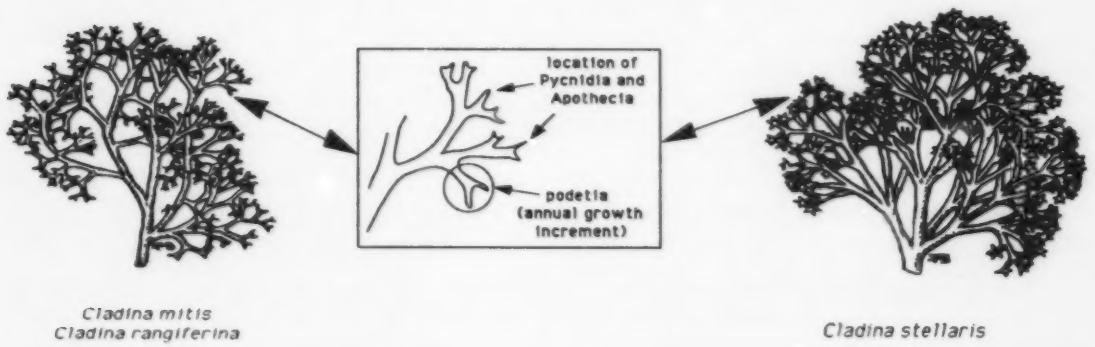

Figure 1. Diagram of *Cladina rangiferina*, *C. mitis*, and *C. stellaris*.

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VMAP
Vegetation Management Alternatives Program

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DESCRIPTION

General: Lichens consist of algae and fungi living in a symbiotic relationship (Ahti and Hepburn 1967; Hale 1977,1979; Smith 1962). The reindeer lichens have a fruticose growth form; they are erect, much-branched, "shrubby" ground lichens forming extensive colonies of intertwined stems. They are perennial with most of the plant structures above ground (Ahti and Hepburn 1967). They do not have roots (Hale 1977). Stems are rounded in cross section, hollow surfaces appearing "cottony", with finely branched podetia, the branch angles open (Baldwin and Sims 1989). Colonies often form intricately branched, circular mats (Thomson 1967).

Reindeer Lichen Bodies: Reindeer lichen bodies (thallus) do not differentiate into leaves or stems (Hale 1979) but are composed of fungal threads forming a distinct pale yellowish, greenish or grey coloured body (Figure 1). Reindeer lichen thalli consist of simple or divided branches (podetia) that are hollow and usually bushy, hairy, or strap-shaped (Hale 1979, Thomson 1967). Chlorophyll content of lichens is one quarter to one half that of leaves of vascular plants (Hale 1977).

Reproductive Structures: Reindeer lichens have two kinds of reproductive structures. Apothecia are cup- or disc-shaped bodies, 1 to 20 mm in diameter, located at the tip of the podetia (Figure 1). Pycnidia are flask-shaped structures found on the upper surface of the podetia and are often difficult to identify with the naked eye (Hale 1977,1979).

Spores: The apothecia contain sterile thread-like paraphyses and asci. Each ascus contains 1 to 8 spores approximately 0.5 mm in length (Hale 1977, 1979).

Reindeer Lichen Species

Cladina rangiferina (L.) Harm.
Ashy-grey thallus with podetia 6 to 10 cm high, branching in four's, forming scattered entangled masses without discrete heads, but with a main stem. Pycnidia common, apothecia very rare (Baldwin and Sims 1989; Hale 1979).

Cladina mitis (Sandst.) Hale & Culb.
Similar in form to *C. rangiferina* but distinguishable by its yellowish-grey colour (Baldwin and Sims 1989). Forms extensive colonies of podetia 4 to 8 cm tall; branches in three's, rarely four's (Hale 1979).

Cladina stellaris (Opiz) Brodo
Yellowish-grey lichen forming distinct, compact, coral or cauliflower-like heads 2 to 3 cm in diameter. Podetia pale yellowish grey 6 to 10 cm high, forming separate or loosely clumped colonies (Baldwin and Sims 1989; Hale 1979).

HABITAT

Distribution in Ontario (from Ahti and Hepburn 1967):

***Cladina rangiferina*:** Very common all over northern Ontario, it is the most widely distributed ground lichen in the area (Figure 2).

Cladina mitis: One of the most abundant lichen in Ontario, its optimum habitat is the central and northern parts of the northern coniferous forest. It is especially abundant in the Sioux Lookout and Kenora Districts, common on rocks, in lichen woodlands, and on dry bog hummocks (Figure 2).

Cladina stellaris: Extremely abundant north of a line between Attawapiskat and Big Trout Lake in northern Ontario, scattered throughout the tundra. This lichen is widely distributed across Ontario but not very abundant south of the middle Boreal forest and loses dominance south of the Patricia District (Figure 2).

Cladina rangiferina
Cladina mitis

Cladina stellaris

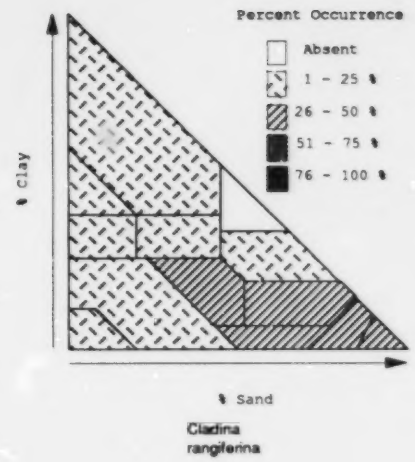
Figure 2. Distribution of *Cladina rangiferina* and *C. mitis*, and *C. stellaris* (from Ahti 1961) in Ontario.

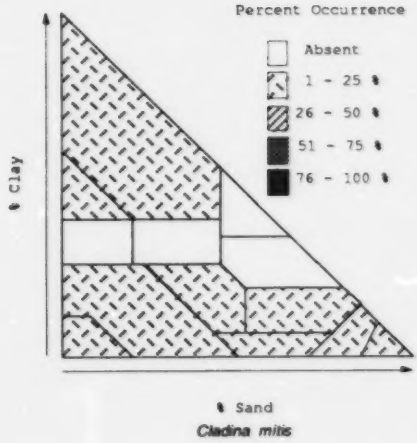
Climate: The reindeer lichens prefer cool, moist conditions, with high relative humidity, but are tolerant of extremely dry situations (Coupe *et al.* 1982). Optimal temperatures for respiration are between 10 and 20°C, but lichens survive much lower temperatures (Hale 1977).

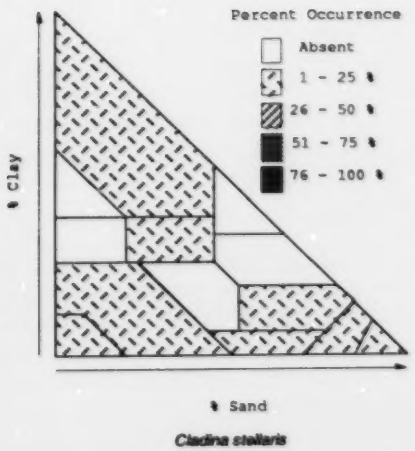
Site and Soil Relations: Reindeer lichen woodlands develop on well-drained nutrient-poor soils (Rencz and Auclair 1978) where competition from mosses and vascular plants is low and tree density is limited by lack of moisture or shallow soil. They are more abundant on shallower, drier soils and rock outcrops of the central and western Boreal zone, with the northern Boreal zone being optimum (Coupe *et al.* 1982). In northwestern Ontario (NWO), reindeer lichens are most abundant on well-drained sands (Forest Ecosystem Classification (FEC) soil type S1 and S2) (Sims *et al.* 1989), especially eskers, sand dunes, and outwash plains. They are also common on rock outcrops (NWO FEC soil type SS1, SS2, SS3) (Harris 1991). Dry peatlands also support extensive ground lichen stands, particularly in the extreme northern part of the province (Ahti and Hepburn 1967). *Cladina stellaris* is associated with sandy soils (Kershaw and Rouse 1971). *Cladina mitis* is common on rocks, in lichen woodlands, and on dry bog hummocks (Ahti and Hepburn 1967), while *C. rangiferina* has a wide ecological tolerance and is found in wet bogs and shaded woods as well as drier habitats. The percent occurrence of these species on different soil textures in NWO can be seen in Figure 3. Reindeer lichens cannot colonize bare rock but require a thin humus or mineral soil layer for attachment (Ahti and Hepburn 1967). Preferred substrates include humus, dead wood and mineral soil.

Nutrient Requirements: Nutrients are supplied by substances dissolved in precipitation that come in contact with the thallus, and are absorbed through the surface. The nitrogen compounds that are important for nutrition are not known. The nitrogen-fixing capabilities of the blue-green algae component of lichens enables them to survive on nutrient-poor sites (Figure 4). Carbon is photosynthesized by the algae and made available to the fungal component. Lichens have the ability to absorb ions in quantities greater than their needs and may have a high need for magnesium and calcium (Hale 1977). Reindeer lichens are low in protein and high in carbohydrates (Godwin 1990).

Moisture Requirements: Reindeer lichens are adapted to dry conditions (Hale 1977) but need to be hydrated to metabolize (Smith 1962). Atmospheric moisture is important since lichens do not have true roots but absorb moisture through the thallus surface; thus, atmospheric moisture is more important than soil moisture (Ahti and Hepburn 1967). There does not appear to be any special structure that can control or retard water loss, although lichen from warm dry habitats are more drought resistant than those from cool moist habitats (Hale 1977). Reindeer lichens are susceptible to rapid and extreme fluctuations in moisture content (Foster 1985), becoming "dormant" when experiencing moisture stress, and resuming photosynthesis when rehydrated (Hale 1977). Their ability to survive water stress gives reindeer lichens







a competitive advantage over other organisms on dry sites. They often occupy very dry sites and are good indicators of site moisture regimes (Rudolph 1974) (Figure 4). Alternating wet and dry conditions in the proper proportion is critical (Smith 1962).

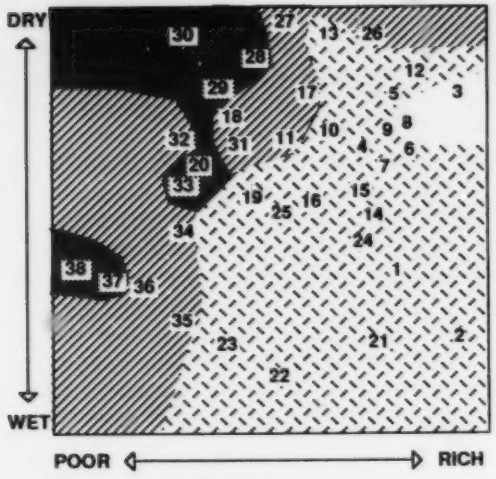
Light Requirements: Reindeer lichens require full sunlight and are outcompeted by feathermosses on shaded sites (Ahti and Hepburn 1967). *Cladina mitis* and *C. stellaris* are not found in mature, closed-canopy stands (Carleton and Maycock 1981). They are common in open, upland stands of jack pine (*Pinus banksiana* Lamb.) and black spruce (*Picea mariana* (Mill.) B.S.P. (Kershaw and Rouse 1971). *Cladina rangiferina* is the most tolerant of the reindeer lichens and can grow in shaded microsites and in competition with feathermoss (Ahti 1961).

REPRODUCTION

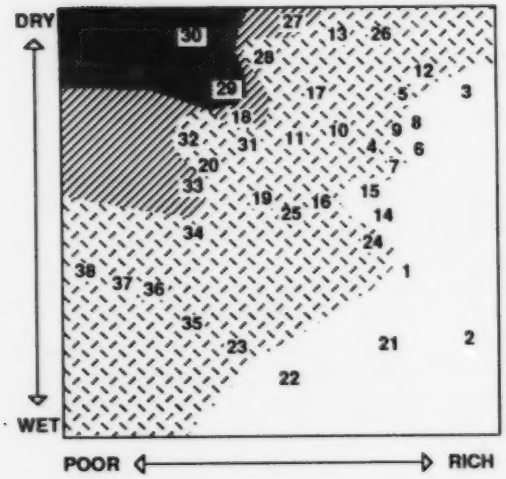
Sexual Reproduction: Sexual reproduction is not well understood but probably occurs infrequently (Hale 1977). The fungal part of the lichen releases spores which must germinate and then undergo "lichenization" with an algae to produce a new lichen (Hale 1977, 1979).

Vegetative reproduction: Reindeer lichen species reproduce primarily by thallus fragments (Thomson 1967). Dry patches of reindeer lichen are easily crushed and each fragment has the potential to become a new lichen when distributed by the wind. Clonal reproduction by budding has been described by Yarranton (1975). Pycnidia, asexual structures, contain specialized cells which are budded off into a chamber, released into the environment and dispersed by wind.

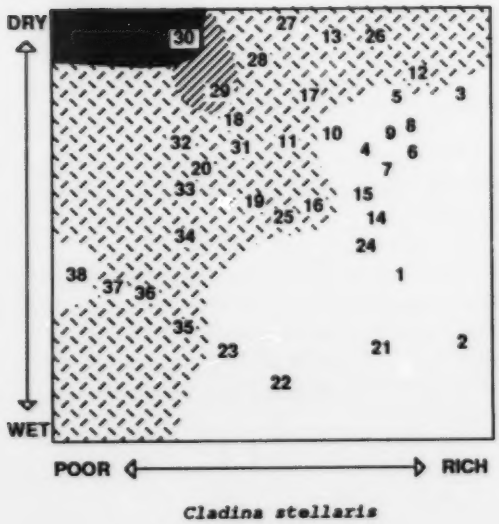
Figure 3. Frequency of occurrence of a) *Cladina rangiferina*, b) *C. mitis*, and c) *C. stellaris* in northwestern Ontario by soil texture.



Cladina rangiferina



Cladina mitis



Cladina stellaris

GROWTH AND DEVELOPMENT

The reindeer lichens grow continuously in length (Hale 1977) and form colonies that have a centrifugal growth pattern. There are three periods of growth (Andreev 1954, Hale 1977):

1. Accumulation period: podetium lengthens for several years. Branches occur at the tip of podetium so that each joint represents one year of growth. Successive lower branches elongate somewhat as well (Vitt *et al.* 1988). This phase occurs for an average of 10 years (Thomson 1967).

2. Period of renewal: base of podetium decomposes at the same rate as the podetia grow. Renewal may continue for several decades to a century (Thomson 1967).

3. Period of degradation: decomposition rate is faster than the growth rate (Andreev 1954, Hale 1979), lasting from 10 to 20 years.

Growth of lichens is slow and depends on climate, competition and light availability (Thomson 1967). Slow growth is due to low photosynthetic rate, moderate dark respiration rate, poor nutrient status and water requirement for metabolism (Smith 1962) and varies from 1 to 8 mm/yr (Scotter 1963). The following annual podetia length growth rates (mm/yr) for reindeer lichens in Ontario have been observed: C. rangiferina 6.2 (Ironside 1971), C. stellaris 5.0 (Yarranton 1975).

PHENOLOGY

Lichen Body: Growth occurs primarily in spring and autumn when optimum moisture and temperature conditions exist (Hale 1977).

No evidence of winter hardening is available (Kershaw 1985) although energy conservation measures have been observed in *Cladina stellaris* and *C. rangiferina*.

Reproductive Structures: The greatest amount of sporulation occurs in the spring (Hale 1977). There does not appear to be any seasonal relationship between pycnidia maturation and dispersal (Hale 1977).

Figure 4. Percent occurrence of a) *Cladina rangiferina*, b) *C. mitis*, and c) *C. stellaris* in northwestern Ontario by NWO FEC vegetation types.

RESPONSE TO DISTURBANCE

Overstory Removal: Extreme temperatures, drought, and intense sunlight slow lichen growth, and may reduce survival after overstory removal (Eriksson 1975, Kershaw 1977). Enns (1990) suggested that survival in central British Columbia cutovers is poor, except where lichens are sheltered by residual trees. In contrast, survival appears to be high in northwestern Ontario, where the climate is wetter (Harris, in prep.). Here lichen biomass may increase after logging in response to increased light availability. Changes in relative abundance of *Cladina* spp. are expected, with *C. mitis* increasing due to its tolerance of dry conditions, and *C. rangiferina* decreasing because it prefers more mesic habitats. Increased wind exposure in cutovers can cause lichens on ridges to be blown away (Barclay 1991, pers. comm.).

Fire: Lichens are completely consumed by intense fire (Morneau and Payette 1989). The blackened ground surface and extreme microclimate may also reduce lichen survival (Eriksson 1975). Post-fire succession of lichen communities generally progresses from crustose species to cup lichens (*Cladonia* spp.) and finally *Cladina* spp. *Cladina mitis* often dominates first, followed by *C. rangiferina* and *C. stellaris* (Foster 1985). *Cladina* recovery is usually limited by slow reinvasion by wind-blown fragments which may take 5 to 25 years (Bergerud 1971, Carroll and Bliss 1982, Johnson 1981, Morneau and Payette 1989). Once established, lichens reproduce by cloning (Yarranton 1975) and the original biomass is recovered after 30 to 100 years (Bergerud 1971, Carroll and Bliss 1982, Johnson 1981, Morneau and Payette 1989).

Mechanical Site Preparation: Heavy scarification such as trenching or blading destroys 50% or more of the lichens by exposing large amounts of mineral soil and depositing soil and humus on unscarified strips (Eriksson 1975, Harris in prep.). Lighter methods, such as Bracke and light drags, cause less damage.

By crushing lichen patches, mechanical site preparation creates fragments which are distributed by wind and recolonize disturbed sites. Recolonization of humus and dead feathermoss is initiated within 5 years.

A shallow layer of loose soil is necessary for lichens to prosper on rocks (Ahti and Hepburn 1967). Scarification techniques causing erosion of soil on outcrops will slow lichen regeneration.

Cutting: Skuncke (1969) recommended a 6 to 8 year rotation of reindeer grazing or manual cropping to encourage vigorous growth in *Cladina* stands. Older lichens grow more slowly and are less palatable to reindeer.

Chemical Treatments: Hristienko (1985) suggested that herbicide use for silvicultural treatments should be limited since lichens are susceptible to toxic compounds and have no means of excreting them. Hawksworth and Rose (1976) concluded that agricultural herbicides can eliminate lichens, but did not provide details.

2,4-D: There is no information in the literature on the effects of 2,4-D on reindeer lichens.

Hexazinone: Corcoran (1991, pers. comm.) did not observe any changes in condition of reindeer lichens on sites treated with hexazinone, although no studies were conducted to note the persistance of this herbicide in the lichen thallus or effects of the herbicide on lichens.

Glyphosate: Harris (in prep) examined four sites which had been treated with Vision® and Roundup® three to five years previously, but could conclude only that reindeer lichens were still present. By controlling vegetation, the effect of herbicides on lichens could be positive. Siltanen *et al.* (1981) sampled reindeer lichen 13 months after treatment with glyphosate at rates of .25, .75, and 2.25 kg a.i./ha and found that residues increased with higher doses. Residues in lichen were significantly higher than those observed in berries. Response of the lichens was not reported.

Triclopyr: Residues were found to be .15, 1.0, and 1.7 ppm in reindeer lichen after treatment with Triclopyr at rates of .25, .75, and 2.25 kg a.i./ha respectively (Siltanen *et al.* 1981) and were much lower than residues of glyphosate. Reindeer lichen response was not reported.

EFFECTS ON CONIFERS

The most obvious effect of lichen on conifers is that of seedbed condition. A thin mat acts as a mulch and moderates soil moisture and temperature, thereby enhancing seed germination and growth (Bonan and Shugart 1989; Cowles 1982; Rouse and Kershaw 1971). However, Chrosciewicz (1989) suggested that reindeer lichen are subject to extreme fluctuations in moisture content and impede jack pine seed germination and survival. Also, a thick mat acts as a physical barrier preventing the roots of the seedling from reaching the moist mineral soil (Foster 1985). Fisher (1979) found that reindeer lichen ground cover reduced growth of both seedlings and transplants of jack pine and white spruce (*Picea glauca* (Moench) Voss.). The yellowish colour and reduced growth of conifers in a lichen-dominated site was attributed to lichens as opposed to "poor" site conditions. *Cladina stellaris* and *C. rangiferina* significantly reduced growth of seedlings as well as concentrations of nitrogen and phosphorous. Mycorrhizal growth and number was also reduced. Several authors have noted that *C. stellaris* maintains an open-canopy habitat (Foster 1985; Kershaw 1977, 1978; Kershaw and Rouse 1971) by inhibiting spruce seeding and layering.

Allelopathic effects of lichens on conifer germination and growth are not well understood. In a study by Brown (1967), extracts from *Cladina stellaris*, *C. mitis*, and *C. rangiferina* did not inhibit germination of jack pine seeds. However, a substance extracted from *Cladina stellaris* did inhibit growth of pine and spruce by altering pH and mannitol content of the seedlings (Brown and Mikola 1971). O'Brien (1985) found that *Cladina stellaris* and *C. rangiferina* both contained extracts that reduced germination and growth of tree seedlings. *Cladina stellaris* exerted the strongest inhibitory influence, where jack pine was least affected and trembling aspen (*Populus tremuloides* Michx.) was most affected. A study by Cowles (1982) in a lichen woodland illustrated that allelopathy was a real phenomenon but that it was not a dominant factor for the growth of spruce.

The flammability of reindeer lichens is important in carrying fire through a stand otherwise lacking in suitable fuel to sustain fire (Dyrness and Norum 1983), and is therefore important in the boreal system where stands are fire dependant (Rowe and Scotter 1973).

USES BY WILDLIFE

The reindeer lichens (*Cladina rangiferina*, *C. mitis*, and *C. stellaris*) are the most important winter food for woodland caribou (Bergerud 1974, Ahti and Hepburn 1967, Johnston and Rowe 1975, Miller 1976). Mature and over-mature conifer/lichen stands provide critical caribou winter habitat (Godwin 1990).

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GLOSSARY: (from Hale 1979)

Apothecium: The reproductive structure of the ascomycete, usually cup- or disc-shaped. This structure is very small and often absent on reindeer lichens.

Ascomycete: the fungal component of reindeer lichen.

Ascus: a sac containing spores, approximately 20 to100 microns long.

Microconidia: uninucleate bacilliform cells produced in pycnidia that are only a few microns long.

Paraphyses: sterile threadlike hyphae found inside apothecia.

Podetium: a hollow simple or branched upright structure.

Pycnidia: small, flask-shaped asexual structures in the inner part of the thallus.

Thallus: the plant body of lichens.

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